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A PHYSICAL EVALUATION OF THE THREE PRINCIPAL METHODS OF EXPORTING DRY EDIBLE BEANS BY VAN CONTAINERS

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This project represents the continuation of a study initiated by the former Transportation and Facilities Research Division. It is part of an overall program of the Agricultural Research Service designed to find more efficient and less costly methods of packaging, handling, and transporting agricultural products. Today, this type of research is being continued under the auspices of the Market Operations Research Laboratory, Agricultural Marketing Research Institute, Agricultural Research Service.

The publication of this report on the physical properties of the principal bean export methods was made possible through cooperative research that united ARS and the following organizations:

Foreign Agricultural Service, USDA
Furnes, Withy, and Company
Michigan Bean Commission
Michigan Bean Shippers Association
Michigan Department of Agriculture
Michigan State University
United Kingdom Research Committee

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A PHYSICAL EVALUATION OF THE THREE PRINCIPAL METHODS OF EXPORTING DRY EDIBLE BEANS BY VAN CONTAINERS

By Joseph P. Anthony, Jr., Russell H. Hinds, Jr.,
and Robert C. Mongelli[1]

SUMMARY

Two series of three experimental export shipments were made of dry edible beans loaded in van containers. Temperatures and relative humidities were recorded during the voyages. The performance of multiwall paper bags, burlap bags, and bulk were measured and compared.

In the first series of tests (comparing burlap and paper bags), temperatures were similar in the bags in the two van containers in each test shipment. In test shipment 1, the average temperature was slightly higher in the multiwall paper bags than in the burlap bags. However, in test shipment 2, the opposite was true.

Humidities were similar in the load in the two van containers in each test shipment in the first series also. In both test shipments 1 and 2, the average humidity in the load was slightly higher in the van container loaded with burlap bags than in the van container loaded with paper bags.

Analyses and tests of the beans after their arrival in the United Kingdom indicated that their moisture content ranged from 15.5 to 18.0 percent, an acceptable range, and that their flavor also was acceptable.

These tests indicate that the use of multiwall paper bags in containerized export shipments of dry edible beans is feasible.

In the second series of tests that compared burlap bags and bulk, temperatures in the bags and in the loads in each test shipment were similar. In test shipments 1 and 2, the average product temperature was slightly higher in the bulk beans than in the burlap bags. Nevertheless, in test shipment 3, the opposite was true.

Relative humidities in the load in the two van containers in each test shipment also were similar. In all three test shipments, the average humidity in the load was slightly higher in the van container loaded with bulk beans than in the van container loaded with burlap bags.

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Analysis of the beans after arrival in the United Kingdom indicated that their moisture content ranged from 16.1 to 17.6 percent, an acceptable range, and that their flavor after canning was rated acceptable. The receiving firms were pleased with the arrival condition of the bulk beans and indicated that they would receive bulk shipments in the future. These tests indicate that the use of van containers for bulk export shipments of dry edible beans is physically feasible.

INTRODUCTION

Exports of agricultural products are of major importance to U.S. agriculture and the U.S. balance of international payments. In 1971-72, 2,810,000 hundredweight of U.S. dry edible beans were marketed in foreign countries. Of a total domestic production of 18,150,000 hundredweight, over 15 percent of the U.S. crop moved into foreign markets. Of the exports of dry edible beans, 676,000 hundredweight were sold in the United Kingdom, one of the largest customers for dry edible beans. The State of Michigan, the United States' leading producer of dry edible beans, is the principal supplier to this British market.

Traditionally, Michigan shippers have packaged beans in burlap bags and loaded them into the holds of ships for break-bulk shipments. The strength and protection imparted to the product by the burlap bags have been needed because of the multiple, rough handlings that occur in such shipments and because of the deteriorating effects of frequent exposure to saltwater or to high-humidity conditions.

Since 1970, the availability of break-bulk service to Michigan ports has declined, and more shippers are compelled to use van container service. However, inadequate information was available on the temperatures and relative humidities that occurred in containerized shipments of beans sent to Europe. In addition, adequate information was not available concerning the possibility of successfully using less costly packaging than burlap bags in containerized shipments. Inasmuch as bags are handled only two or three times in containerized shipments, as compared with six to eight times in break-bulk shipments, the strength provided by burlap bags, especially considering their higher costs, might be unnecessary.

In 1970 and again in 1971, the Agricultural Research Service conducted a series of three paired and instrumented experimental shipments of van containers loaded with burlap bags and paper bags. These tests demonstrated the feasibility of using multiwall paper bags in containerized export shipments.2/ Information from these preliminary experiments is included in this report and is described as the "first series of tests." It was included to enable one to compare paper bags and bulk by using the burlap bag control shipments as a point of reference.

2/ Anthony, J. P., Jr., Hinds, R. H., Jr., and Goddard, W. F., Jr. A Comparison of Burlap and Paper Bags in Exporting Dry Edible Beans by Van Containers, ARS-NE-10. 8 pp. April 1973.

The purpose of this study was twofold: (1) to measure the temperatures and relative humidities in containerized shipments of beans sent to Europe and (2) to test the physical feasibility of shipping dry edible beans in bulk in van containers by comparing their performance in shipments with the performance of burlap bags.

PROCEDURE

In the first series of tests, three experimental ocean shipments were made from Michigan to the United Kingdom. Each test shipment consisted of two van containers, one loaded with beans packaged in 400 burlap bags and the other loaded with beans packaged in 400 multiwall paper bags. The shipments were made during August and October 1970 and again in January 1971.

In the second series of tests, three experimental ocean shipments were made from Michigan to the United Kingdom. Each test shipment consisted of two van containers, one loaded with beans packaged in 400 to 413 burlap bags and the other loaded with 40,000 to 41,500 pounds of bulk beans encased in a disposable plastic liner. The shipments were made during July and October 1971 and again in January 1972.

These particular shipments illustrate the multimodal nature of containerized transportation. After being loaded near Saginaw, Mich., the van containers were moved by truck to Detroit. A barge carried the vans to Windsor, Ontario, where they were placed on a flatcar and taken to Montreal, Quebec. From there, they were stowed below deck aboard a container ship and carried to the United Kingdom. A truck completed the shipment by taking the van containers from the dock to the designated processing plant in the United Kingdom for unloading.

Temperatures and relative humidities were measured throughout the journey. A portable potentiometer and a cable of thermocouple leads in each van container were used to measure the temperature. A portable humidity sensor was used to measure relative humidity (fig. 1).

A British industry committee (United Kingdom Research Committee) composed of the quality control managers of the firms that were to receive the test shipments determined through scientific analysis the moisture content and canning quality (including percentage defective, percentage of splits, and flavor) of the beans at destination.

DESCRIPTION OF BAGS AND VAN CONTAINERS

The burlap bags tested had a capacity of 100 pounds. They were made of one piece of material, 40 inches wide, that weighed 10.0 ounces per running yard. All seams were securely stitched (seven stitches every 2 inches) with cotton twine and were double-lapped where the cut edges of the material were seamed. The completed bag was a 21- by 36-inch flat tube. All bags were marked in accordance with railroad tariff specifications.

The multiwall paper bags tested also had a capacity of 100 pounds. The bags were constructed of four walls or plies of not less than the following basic weights:

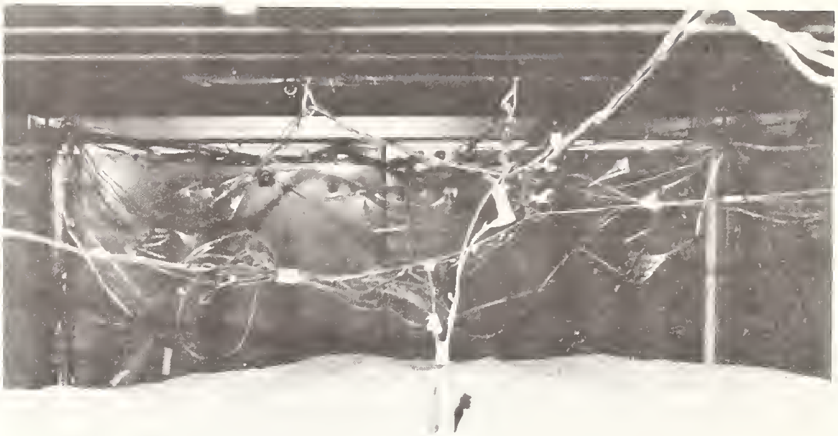

Figure 1.--Cable of thermocouple leads and humidity sensor in an experimental bulk shipment of beans.

Inner wall: 50-pound kraft ribbed paper.
Intermediate wall: 50-pound extensible kraft paper.
Intermediate wall: 50-pound kraft paper.
Outer wall: 40-pound kraft paper.

The walls or plies were fabricated in tube form, one within the other. The longitudinal seam had not less than a 1-inch overlap. All seams, excluding the top seam, were securely fastened with a waterproof adhesive. The completed bag was a 21- by 38-inch flat tube. In the first series of tests, all bags were marked in accordance with railroad tariff specifications.

The metal van containers used to transport the dry edible beans in bags were nonvented, partly insulated, dry freight containers that had the following specifications:

Outside dimensions:	19 feet 10½ inches long by 8 feet wide by 8 feet high.
Inside dimensions:	19 feet 4½ inches long by 7 feet 7½ inches wide by 7 feet 4 inches high.
Rear door aperture:	7 feet 1 inch high by 7 feet 6 inches wide.

The metal van containers used to transport the dry edible beans in bulk were nonvented, partly insulated van containers with the following specifications:

Outside dimensions:	19 feet 10½ inches long by 8 feet wide by 8 feet high.

Inside dimensions: 19 feet 3½ inches long by 7 feet 8½ inches wide by 7 feet 3¼ inches high.

Rear door aperture: 7 feet 1/4 inch high by 7 feet 8½ inches wide.

This steel bulk van container serves the primary purpose of a standard van container and has the added advantage of being able to handle suitable bulk materials. Twin weathertight hatches allow top loading. Unloading is achieved by the use of a tipping vehicle, the load being discharged through a slot at the front of the container. An open-top plastic liner was provided by the carrier with each bulk container to protect the beans from contamination and from condensation.

TEMPERATURE AND RELATIVE HUMIDITY

For the first series of tests, the average outside air temperatures and temperatures taken inside the bags of beans in the van containers for test shipments 1 and 2 are shown in table 1. The temperature-and humidity-measuring equipment used in test shipment 3 failed during transit, so that no intransit data from this shipment were included.

TABLE 1.--Range and average of outside air temperature and of temperatures inside the bags of beans at various locations in two van containers loaded with dry edible beans packaged in burlap bags and paper bags, test shipments 1 and 2, Michigan to the United Kingdom

Location of thermocouples	Shipment	Temperatures in container with			
		Burlap bags		Paper bags	
		Range	Average	Range	Average
	Number	°F	°F	°F	°F
In outside air	1	60.0-91.0	70.0	61.0-97.0	70.9
	2	48.0-58.0	49.1	46.0-57.0	50.8
In bags of beans:					
Front	1	62.8-86.6	72.8	64.4-87.0	73.5
	2	48.4-55.6	51.7	46.6-57.6	51.1
Middle	1	64.4-86.3	73.6	65.6-86.0	74.1
	2	47.8-57.3	52.9	48.0-55.9	51.5
Rear	1	63.6-85.0	71.4	63.4-85.4	72.4
	2	46.8-57.3	52.7	46.7-59.5	51.5

Temperatures in the bags in the two van containers in each test shipment were similar. The average temperature in the multiwall paper bags in test shipment 1 was 0.7° F higher than the average in the burlap bags. In test shipment 2, the average temperature in the paper bags averaged 1.1° F lower than in the burlap bags.

Temperatures in the bags responded to changes in air temperatures outside the van containers. For example, the outside air temperatures during the loading of test shipment 1 averaged 81.5° F, and the temperatures in both types of bags averaged 74.1°. However, during the latter two-thirds of the trip, outside air temperatures ranged from the low 70's down to the low 60's, and by the time the van containers were unloaded, the temperatures in the bags had dropped to an average of 64.3° F.

The average relative humidity at two locations in the van containers is shown in table 2. There was an inverse relationship between the relative humidities in the van containers and the temperatures in the van containers. As temperature rose, relative humidity fell and vice versa. The relative humidity in the load fluctuated much less than it did in the air above the load.

TABLE 2.--Relative humidity at two locations in van containers of dry edible beans packaged in burlap bags and paper bags, test shipments 1 and 2, Michigan to the United Kingdom

Location of sensors	Shipment	Relative humidity in container with			
		Burlap bags		Paper bags	
		Range	Average	Range	Average
	Number	Percent	Percent	Percent	Percent
Above the load	1	26-99	75.6	33-91	72.7
	2	40-100	81.3	46-100	80.7
In the load	1	67-78	71.3	61-72	67.7
	2	69-72	70.4	62-71	69.1

Above the loads in test shipment 1, the range was from 26 to 99 percent in the van container loaded with burlap bags and from 33 to 91 percent in the van loaded with paper bags. In test shipment 2, the range was from 40 to 100 percent in the van container loaded with burlap bags and from 46 to 100 percent in the van container loaded with paper bags. The average relative humidity in the load in test shipment 1 was 3 percentage points higher in the van container loaded with burlap bags. In test shipment 2, the average was less than 1 percentage point higher in the van container loaded with burlap bags than it was in the van container loaded with paper bags.

In the second series of tests, the average outside air temperatures and temperatures taken in the loads of beans in the van containers for test shipments 1, 2, and 3 are shown in table 3. These data include all points of origin, points intransit, and destination temperatures measurements made during each test shipment.

TABLE 3.--Range and average of outside air temperatures and of temperatures inside the bags and in the loads of beans at various locations in three van containers loaded with dry edible beans packaged in burlap bags and shipped in bulk, test shipments 1, 2, and 3 (second series), Michigan to the United Kingdom

Location of thermocouples	Shipment	Temperature in container with			
		Burlap bags		Bulk	
		Range	Average	Range	Average
	Number	°F	°F	°F	°F
In outside air	1	67.0-95.0	76.5	63.0-95.0	75.8
	2	53.0-72.0	59.9	51.0-70.0	57.4
	3	30.0-68.0	44.2	28.0-68.0	42.8
In burlap bags and bulk load:					
Front	1	60.8-111.4	78.9	53.8-113.2	79.7
	2	54.0-70.0	58.6	51.8-69.6	58.9
	3	26.8-58.4	41.5	28.4-46.2	38.0
Middle	1	58.9-108.1	79.5	54.3-110.4	79.3
	2	54.1-68.0	58.4	52.1-69.7	59.3
	3	30.1-60.3	41.7	28.8-48.6	38.2
Rear	1	62.8-101.6	77.8	54.8-109.2	79.2
	2	53.7-67.7	57.9	52.2-69.2	57.9
	3	28.8-60.8	41.5	27.2-50.0	38.4

The temperatures in the van containers loaded with burlap bags and in those loaded with bulk beans were similar in each test shipment. The average temperature in the load in the bulk van container in test shipment 1 was 0.66° F higher and in test shipment 2, 0.40° F higher than the average in the van container loaded with burlap bags. In test shipment 3, the average temperature in the bulk load was 3.37° F lower than in the burlap bags.

The temperatures in the load and in the bags responded to changes in air temperatures outside the van containers. For example, the outside air temperatures during loading of test shipment 2 averaged 70.3° F, and the temperatures in both types of loads averaged 67.4° F. However, during the latter two-thirds of the trip, outside air temperatures ranged from the low 60's down to the low 50's, and by the time the van containers were unloaded, the temperatures in the loads had dropped to an average of 57.3° F.

The average relative humidity at various locations in the van containers is shown in table 4. In contrast to previous findings on burlap and paper bags in identical test shipments, there was no inverse relationship between the relative humidities and the temperatures in the van containers. The relative humidity in the load fluctuated much less than it did in the air above the load.

TABLE 4.--Relative humidity at various locations in van containers of dry edible beans packaged in burlap bags and shipped in bulk, test shipments 1, 2, and 3, Michigan to the United Kingdom

Location of sensors	Shipment	Relative humidity in container with			
		Burlap bags		Bulk	
		Range	Average	Range	Average
	Number	Percent	Percent	Percent	Percent
Above the load[1]	1	52-84	73.7	46-79	70.2
	2	[2]	[2]	64-99	79.0
	3	3-90	23.0	2-94	11.6
In the load[3]	1	69-77	73.9	74-79	76.0
	2	71-77	74.7	76-78	76.7
	3	7-74	16.9	4-82	23.0

[1] Relative humidity measured at one location above the load in both the bagged and bulk van containers.

[2] Instruments did not function properly during this test.

[3] Relative humidity measured at one location in the bagged van container and at six locations in the bulk van container.

Above the load in test shipment 1, the range was from 52 to 84 percent in the van container loaded with burlap bags and from 46 to 79 percent in the van container loaded with bulk beans. In test shipment 2, the instrumentation in the van containers loaded with burlap bags failed to function. In the van container loaded with bulk beans in test shipment 2, the relative humidity above the load ranged from 64 to 99 percent. In test shipment 3, the range was from 3 to 90 percent in the van container loaded with burlap bags and from 2 to 94 percent in the van container loaded with bulk beans.

The average relative humidity in the load in all test shipments was higher in the van container loaded with bulk beans than in the van container loaded with burlap bags. In test shipment 1, it was 2.1 percent higher; in test shipment 2, it was 2.0 percent higher; and in test shipment 3, it was 6.1 percent higher.

ARRIVAL CONDITION OF BEANS

In both series of tests, the United Kingdom Research Committee reported that no difference was found between the arrival condition of beans shipped in burlap bags (fig. 2) and the condition of beans shipped in either paper bags or in bulk. This finding was substantially the same as that of Johnson and Thompson, who conducted storage tests with beans stored in paper bags for an initial

6-month period in Bay City, Mich., and then for an additional 4-month period in three southern commercial warehouses. The results of the research by Johnson and Thompson showed that the beans exhibited no significant changes during either storage periods compared with those stored in burlap bags.[3]

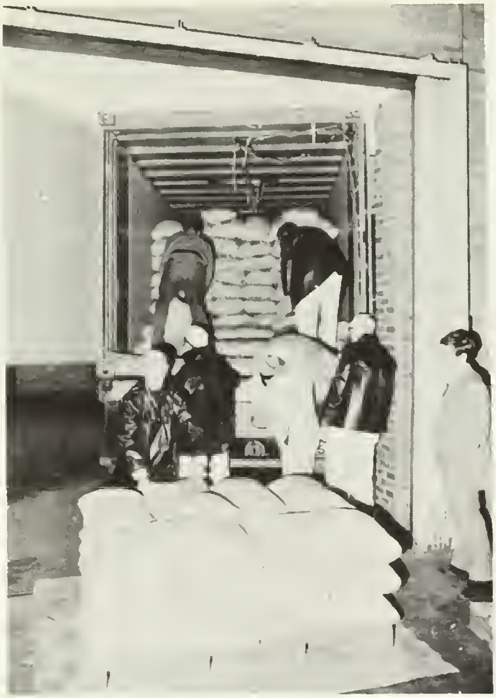

Figure 2.--Burlap bags of beans being unloaded at destination in the United Kingdom.

The United Kingdom Research Committee reported that the moisture content of the beans on arrival ranged from 15.5 to 18.0 percent in the first series of tests and from 16.1 to 17.6 percent in the second series of tests. This range corresponded to the 14- to 18-percent range that previous research indicated is acceptable.[4]

When the beans have a moisture content below 14 percent, their handling may cause an increase in split and cracked seedcoats. When their moisture content is above 18 percent, they are subject to fungicidal disorders.

The committee also reported that no significant differences were found in either of the series of test shipments between the moisture content and the canning quality of beans shipped in burlap bags (including the percentage of defective beans and percentage of splits) and the moisture content and canning quality of beans shipped in paper bags or in bulk (fig. 3).

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[3] Johnson, R. M., and Thompson, J. A. Burlap and Multiwall Paper Bags for Handling and Storing Pea Beans. AMS 528. April 1964.

[4] Thompson, J. A., Sefcovic, M. S., and Kingslover, C. H. Maintaining Quality of Pea Beans During Shipment Overseas. U.S. Dept. Agr. Market. Res. Rpt. No. 519. February 1962.

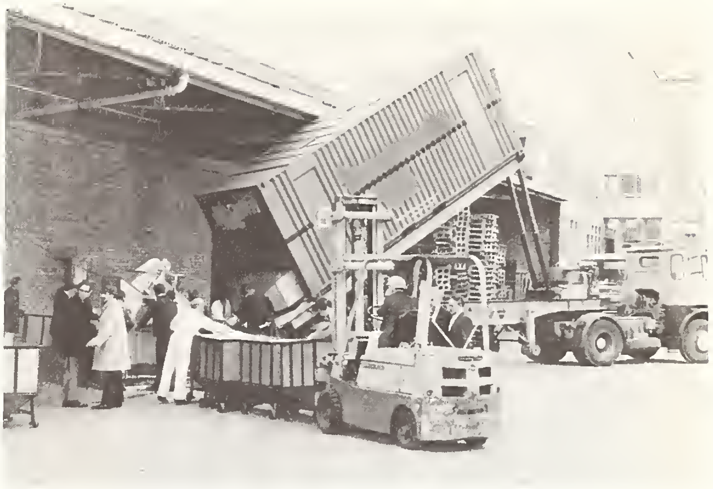

Figure 3.--Bulk van container of beans being unloaded by tilting mechanism at destination in the United Kingdom.

A taste panel sampled the flavor of the beans in all test shipments and rated them acceptable. The receivers were pleased with the arrival condition of the beans and indicated that they will accept future van container shipments in either paper bags or in bulk.

CONCLUSIONS

The test shipments showed that packaging dry edible beans in multiwall paper bags for containerized export shipment is physically feasible. This research also demonstrated that loading and shipping dry edible beans in bulk in van containers, as well as packaging them in multiwall paper bags for containerized export shipment to the United Kingdom, is physically feasible.

The small differences between temperatures in the burlap bags and those in the paper bags were not significant. Neither were the slight differences in relative humidity in the air above the loads in the vans that contained the respective types of bags.

The test shipments also confirmed that the use of van containers is a satisfactory method for shipping dry edible beans from production areas in the United States to processing plants in the United Kingdom.

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